THE WEATHER AND CIRCULATION OF MAY 1952[1]

Including a Study of Some Recent Periodicities

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GENERAL CIRCULATION CHARACTERISTICS

The mean circulation pattern for May 1952 was characterized by low zonal index and blocking activity from central Europe westward through North America. These conditions were accompanied by a large area of persistently above-normal 700-mb. heights extending from Scandinavia to central Canada (fig. 1) and a strong narrow band of westerlies at lower latitudes (south of 40° N.) across the Atlantic sector. Along this narrow channel, the strongest 700-mb. jet on the map (fig. 2), moved almost all of the cyclones which passed eastward off North America (fig. 3 and Chart X). Only a few of these storms ever completed the customary northeastward trajectory to the Greenland-Iceland area. Most were shunted eastward, far south of the normal path, in the area of below-normal 700-mb. heights (fig. 1). Many of these stalled and filled in the central Atlantic as a result of the prevailing blocking regime. This characteristic is in accord with the findings of Rex [1] who showed that May is an especially favored month for blocking activity.

[1] See charts I–XV following p. 93 for analyzed climatological data for the month.

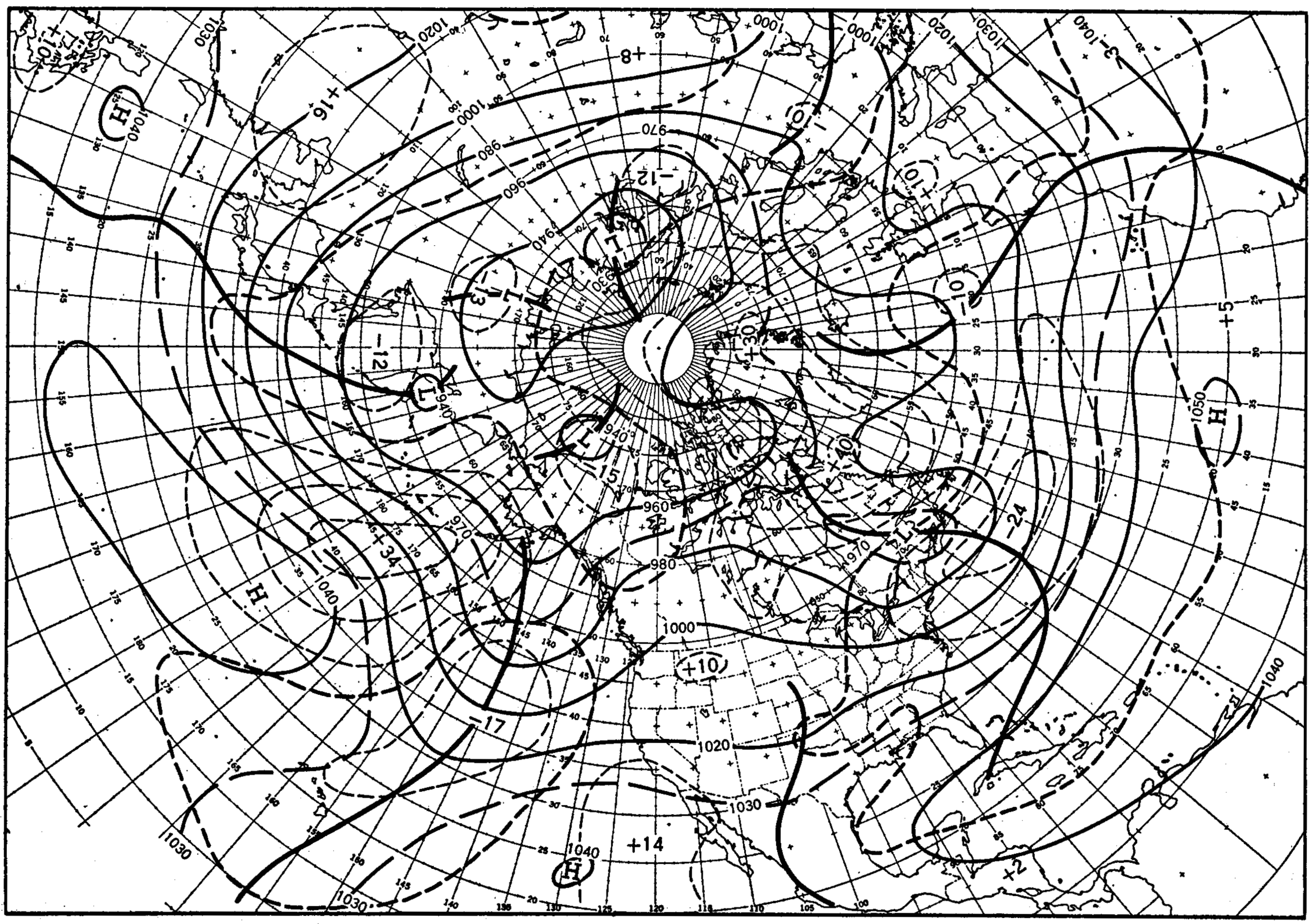

FIGURE 1.—Mean 700-mb. chart for the period April 29—May 28, 1952. Contours at 200-ft. intervals are shown by solid lines, intermediate contours by lines with long dashes and 700-mb. height departures from normal at 100-ft. intervals by lines with short dashes with the zero isopleths heavier. Anomaly centers and contours are labeled in tens of feet. Minimum latitude trough locations are shown by heavy solid lines.

The western Atlantic was thus the scene of the strongest trough and ridge activity on the map. The warm blocking High in the Davis Strait had the greatest 700-mb. height anomaly (+400 ft.) observed in the Northern Hemisphere. At middle latitudes, in the trough south of Newfoundland, heights averaged 240 feet less than normal. This trough was some 10° to 15° of longitude farther east than its counterpart in April [2]. The major eastern Pacific trough (fig. 1) was also slightly farther east in May (about 5° in middle latitudes) than the analogous April feature, so that the large-scale patterns had some similarity during the 2 months. However, the low-latitude segment of this trough, near the Hawaiian Islands, was much farther west than the trough off California in April. Consequently, the prevalence of blocking activity, which augmented the seasonal weakening of the westerlies, and the increasing wave length, as the lower latitude troughs separated, favored a new trough development. In May such a new trough development did take place, from the Central Plains of the United States southward, and it became more conspicuous as the month progressed.

The eastern Pacific trough was accompanied by stronger than normal cyclonic activity (below-normal heights, fig. 1, below-normal sea level pressures, Chart XI inset) and was associated with a well-marked westerly jet stream (fig. 2). This stream, while traversing the western North American ridge, did not show the well-defined split into two parts which was noted in April. Instead, it appeared to disintegrate over the continent, with three weakly marked maxima penetrating the ridge. Its reestablishment and emergence from eastern North America was closely associated with the strong confluence of warm and cold air streams over the eastern United States. Some evidence of the thermal characteristics of this mechanism is afforded by the surface temperature anomalies of the eastern United States; Charts I-A and I-B illustrate the much stronger than normal thermal contrast between New England and the southeastern States.

CYCLONE AND ANTICYCLONE TRACKS IN RELATION TO THE MEAN CIRCULATION

Weather systems entering North America from the Pacific were subjected to the influence of the western North American ridge. Only one storm center penetrated the western United States at lower latitudes, traveling eastward north of the weak southern jet shown in figure 2. Farther north, however, several perturbations did manage to cross the Rockies and set off cyclogenesis in northeastern British Columbia and northern Alberta as illustrated by the cyclone frequencies in figure 3. This illustration, showing the major areas of cyclonic activity and axes of storm movement, indicates that Alberta Lows moved either east-southeastward or south-southeastward. The former motion gave rise to the major east-west storm track of south central Canada, which split abruptly over eastern Hudson Bay as the storms came under the influence of the blocking regime near the lower Davis Strait. The south-southeastward moving Alberta Lows entered the United States by way of the Northern Plains, after which both they and their secondaries moved eastward through the weak trough in the Central Plains, across the eastern Lakes, and were finally filled or turned southeastward by the strong northwesterly flow over New England. The lack of cyclonic activity in the warm blocking ridge just south of Greenland is especially noteworthy since this area is seldom so free of storms at this time of the year.

The anticyclonic activity over North America had two apparent phases. Most of the Highs which affected the United States were of distinct maritime origin (see Chart IX) and entered southern British Columbia from the eastern Pacific. They then moved eastward and east-southeastward through southern Alberta, around the upper level ridge, entering the United States through the Dakotas. Their further collective trajectories were ill-defined in the trough area of the mid-United States, but a preferred exit path by way of the eastern Lakes and southern New England was evidenced. The second phase of the anticyclonic activity centered about the Highs of Polar continental origin whose locus of activity appeared to be north-central Canada, south of the northernmost jet (fig. 2) and south of the northernmost storm track (fig. 3). None of these centers entered the United States (Chart IX) although frequent reinforcement of the mP Highs by cP air was evident. Most of these continental anticyclones followed a trajectory eastward and finally merged with the mean blocking high pressure over the Davis Straits and Greenland.

ANOMALIES OF TEMPERATURE AND PRECIPITATION IN THE UNITED STATES

The month of May was predominantly warm. This was particularly true of the early period, before the mid-United States trough developed. Thus the first week of the month had temperatures averaging as much as 15° F. above normal in the Central Plains and effected such rapid drying in the recently flooded Missouri Valley that many fields deemed lost for the season were expected to prove arable. However, the development of the trough in the United States, and the surges of maritime air which followed the accompanying depressions, produced cooler temperatures in the middle and south-central United States areas. This activity, combined with the cloudiness attending the trough development, was sufficient to bring below-normal temperatures to Texas with near normal temperatures northward and northeastward through the Ohio Valley (Charts I-A and I-B). The coldest (relative to normal) area of the country was the Northeast which was dominated by the strong northwesterly flow comprising the cold segment of the confluent streams. Monthly average temperatures as much as 4° F. below normal were reported from eastern New York to northern

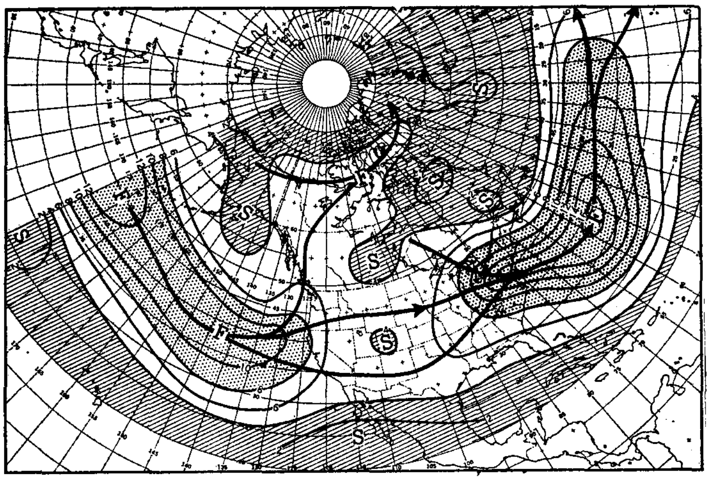

FIGURE 2.—Mean geostrophic (total horizontal) wind speed at 700 mb. for the period April 29–May 28, 1952. Light solid lines are isotachs drawn at intervals of 2 m. p. s., while the heavy solid lines delineate the axes of maximum wind speed (jets). Areas with speeds in excess of 8 m/sec. are stippled while those with less than 4 m/sec. are hatched. Centers of maximum and minimum wind speed are labeled "F" and "S" respectively.

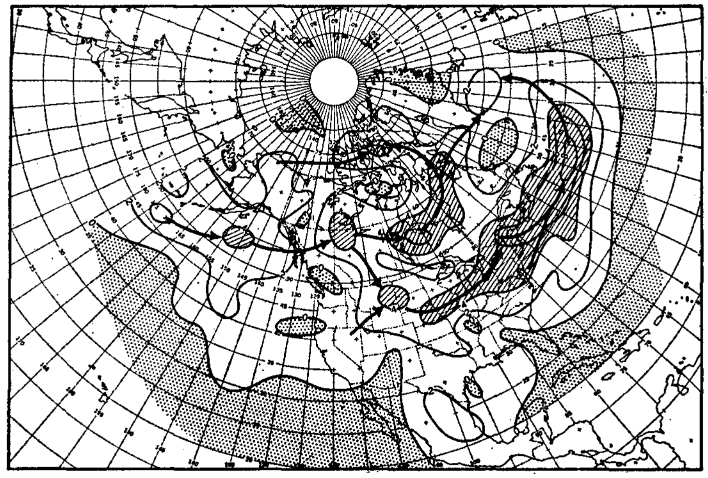

FIGURE 3.—Geographical frequency of tracks of cyclones observed during month of May 1952 within approximately equal area boxes of size 5 mid-latitude degrees of longitude by 5° of latitude. The isopleths are drawn at intervals of 2; areas of zero frequency are stippled, and areas with frequencies of four or more are hatched. The principal cyclone tracks are indicated by solid arrows and are not drawn through the centers for clarity. All data obtained from Chart X.

Vermont and were in part due to the above-normal cloudiness accompanying the overrunning and heavy precipitation north of the prevailing confluence and frontal zone. However, foehn warming east of the Appalachians and the weakness of the sea breeze regime were probably responsible for the above-normal temperatures at coastal stations of New England and the Middle Atlantic States.

The western United States had generally above normal temperature with extremes averaging +6° F. in the lower Colorado and Gila River Valleys. This entire area was one of above-normal 700-mb. heights and abnormally strong upper level anticyclonic circulation (fig. 1) which replaced the more normal lower California coastal trough. Most of the southeastern United States was under a weakly anticyclonic westerly regime which made up the warm component of the confluent streams. Temperatures were consequently above normal despite the fact that 700-mb. heights were slightly below normal and that the anomalous flow was weakly from the northwest.

There were two conspicuous almost zonal bands of above-normal precipitation (Charts II and III). The first or northern band stretched from southern Montana and Wyoming eastward to Iowa, weakening over Illinois, but becoming well marked again from Ohio eastward to the Atlantic Coast and northeastward over New England. The precipitation in the Northeast was about that expected on the cool side of a confluence zone where cyclonic and frontal overrunning theoretically reach a maximum. The western section of the northern band of heavy precipitation accompanied the cyclonic activity and cool air invasions already described. Most of this precipitation occurred around the middle and latter portions of the period as trough conditions in the United States became more dominant.[2] The northern precipitation band was closely aligned with the axes of both the weak 700-mb. jet (fig. 2) and the major storm path (fig. 3).

The second or southern band of above-normal precipitation was chiefly apparent from east Texas eastward across the northern Gulf States to the Georgia coast, with possibly a westward extension in central New Mexico. Gulf precipitation was mostly of the air-mass shower type with a few tornadoes and hailstorms reported. Frequently the activity was associated with warm sector squall lines which accompanied cyclones moving eastward along the main track farther north (fig. 3) The shower activity in New Mexico was most notable as the period ended and the ridge in that area finally weakened. In general, however, the ridge was an effective suppressor of precipitation, and light amounts (or no rain) were observed over most of the Far West and Southwest. Subnormal precipitation, was also observed in the North Central States, in connection with the northwesterly flow east of the mean ridge and the anticyclonic relative vorticity which prevailed at 700 mb. One of the most striking features of Chart III is the zonal band of below-normal precipitation from Kansas to North Carolina, completely separating the two bands of above-normal precipitation to the north and south. This pattern may be related to the split in the westerly jet-stream at 700 mb. (fig. 2).

Over large portions of the nation, the weather was mostly mild and precipitation generally sufficient for agricultural needs. Most areas were reporting excellent farm work progress and favorable growing conditions. Preliminary estimates foretold one of the bumper wheat crops. However, individual areas differed widely and, as often is the case, some localities were suffering acutely from the weather's vagaries; Huron, S. Dak. had the driest May since 1940; Crookston, Minn., the driest since 1917; while Texas was reporting that drought conditions

[2] An adjacent article by Chapman and Carr describes some of this activity in more detail.

were nearly erased in all sections for the first time in 2 years.

A STUDY OF SOME RECENT PERIODICITIES

One of the more interesting and newsworthy aspects of the weather of this month and for some preceding weeks was the succession of rainy weekends which occurred in the eastern United States. On May 25 the New York City Office of the United States Weather Bureau recorded 1.42 inches of precipitation and the fifth rainy Sunday out of the last six. The meteorological observatory at Blue Hill, Milton, Mass., reported precipitation on three of the four Sundays in May with two of the Sundays completely overcast. Washington, D. C. had a similar succession of disappointing weekends, and so did most of the intervening and adjacent areas. Remembering recent discussions [3] of claims of augmentation and control of 7-day weather periodicities through appropriate silver iodide seeding, many wondered if such seeding was still being practiced. As far as could be determined, no comparable periodic seeding was currently under way; indeed, it seems likely that the use of silver iodide generators has become so common and uncontrolled that the effects of additional periodic seeding would be more difficult than ever to detect. However, periodicities in the weather have been noted for a long time and it seemed advisable to examine the recent data and test its periodic nature.

One method of studying 7-day periodicities is to utilize four complete cycles (28 days). Hence, the tests for May included the first 28 days of the month. A sample array of the 24-hour precipitation totals (ending 2400 EST) at the Washington City Office for the first 28 days of May is shown in table 1. The totals show a striking preference for precipitation to occur on Sunday with decreasing amounts on either side and no measurable precipitation on Wednesday and Thursday.

Table 1.—*Accumulated 24-hour precipitation amounts (inches) during first 28 days of May 1952 at Washington, D. C. (city office)*

	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
					T	0	0
	0.29	0.20	T	0	T	.02	.15
	.69	.57	T	0	T	.04	.06
	0	.43	.65	T	0	0	.29
	1.69	0	0	0			
Totals	2.67	1.20	.65	T	T	.06	.50

The analysis was made by a technique commonly employed in testing for periodicities with data composed of a limited set of discrete values [4]. It consisted of fitting a simple cosine curve to the data in such a fashion as to minimize the square of the deviations (of the fitted curve) from the observed values. The 7-day periodic element was then expressed

$$Y = A \cos \frac{360}{7} (x - \theta)$$

where Y = the precipitation in inches (expressed as departure from the mean) for the particular day of the week designated by x

A = the amplitude of the fitted curve in inches of precipitation

x varies from 0, 1, 2, . . . 7 corresponding to Sunday, Monday, Tuesday, . . . Sunday

θ = phase angle expressed in units and tenths where each unit represents a day of the week and Sunday is taken as 0, i. e., Tuesday is 2.0, Wednesday is 3.0, etc., and Sunday is 7.0 or 0.

The cosine function was chosen since θ, the phase angle, would then indicate the day of the week when the precipitation expressed by the equation would be a maximum. For example, if θ is 2.0 the expression $A \cos (x-\theta)\frac{360}{7}$ will be a maximum when $x=2$, since the cos $0°=1$, and Tuesday would be the day when, according to the fitted curve, the maximum precipitation would fall. The amounts of precipitation indicated for each day of the week by the fitted curve were correlated in two ways with the observed data: (1) Correlation (R_7) with the average precipitation for each day of the week, and (2) correlation with the appropriate individual daily amounts for each of the 28 days (R_{28}). The latter is the more critical criterion since it relates the periodic function with each day and indicates whether cyclical indications given by the totals were due to a periodicity consistent in amplitude and phase during the entire period or were due to a few sporadic and fortuitously timed large precipitation amounts occurring on several days of the period.

The following array (table 2) presents the results of such analyses for the first 28 days of May 1952. The stations are tabulated from west to east so that spacial comparisons of phase are facilitated. The amplitudes and R_7 factors are of appreciable dimensions; furthermore, the R_{28} values (especially that for Washington, D. C.) are larger than those usually encountered in chance distributions. Specifically, the probability of the Washington value having occurred by chance from a random distribution is about 1 or 2 in 100. It is also of interest to see if the stations progressively farther east showed a sensible progression of phase, as would be expected from eastward-moving perturbations. This did prove to be the case; i. e., the maximum precipitation at Omaha was

Table 2.—*Amplitude, correlations, and phase angle values computed from precipitation data for selected stations for May 1–28, 1952. (All values are based on 24-hour precipitation totals ending 2400 EST except Omaha which ends 2400 CST)*

Station	A	R_7	R_{28}	θ
Omaha, Nebr. (Muncie Airport)	.185	.854	.437	4.1
Lansing, Mich. (Capital City Airport)	.183	.766	.316	4.5
Cincinnati, Ohio (Abbe Observatory)	.166	.777	.474	6.6
Washington, D. C. (City Office)	.267.	.848	.529	0.4
Atlantic City, N. J	.282	.638	.453	0.3
New York, N. Y. (Battery Pl. Office)	.251	.612	.449	0.3
Boston, Mass. (Logan International Airport)	.171	.900	.418	0.9

on Thursday (plus 1/10 day); at Lansing, halfway between Thursday and Friday; at Cincinnati, about halfway between Saturday and Sunday; at Washington, almost halfway between Sunday and Monday, etc. These phase-space relations (with the exception of Lansing) are in good agreement, especially since single-station precipitation data were used. It seems pertinent to point out that the periodicity in May 1952 precipitation at Washington, D. C. was greater than that noted at Washington in April and May of 1950 when periodic seeding was being practiced [3].

While a 7-day periodicity was definitely present in the May 1952 precipitation, an appraisal of its probability is more complex. The figures quoted above refer to chance occurrences from a random distribution but most meteorological elements are not randomly distributed. Since the evaluation of periodicities in serially corrrelated data is theoretically difficult, the practical procedure is to examine the past records for other occurrences or periodicities with which the current one can be compared [5]. For these purposes April and May precipitation records since 1919 for Washington, D. C., were examined for similar periodicities in the precipitation data. Analyses of 66 months (the Aprils and Mays for 33 years) revealed no periodicity with an R_{28} as high as that for May 1952. They also indicated that the serial correlation in these precipitation data is so small that the assumption of a random distribution gives approximately the correct results, i. e., the analyses indicated that periodicities equal to that of May 1952 may be expected to occur (during April or May) about 3 times in 100.

Next an evaluation of the recent free-air temperature periodicities was made since, in the past, this element has yielded the more striking results [3, 5, 6]. The following findings (table 3), all that could be processed in the time available, are for the 2200 EST 700-mb. temperatures in ° C.

TABLE 3.—*Amplitude, correlations, and phase angle values computed from 700-mb. temperature data (2200 EST) for selected stations* [1]

Station	Month (1952)	A	R_7	R_{28}	θ
Nantucket, R. I.	May	1.860	.872	.282	-------
Dayton, Ohio	May	1.519	.711	.287	-------
Joliet, Ill	May	1.475	.803	.256	-------
Omaha, Nebr	March	2.310	.904	.346	0.0
Omaha, Nebr	April	3.077	.993	.545	1.1
Omaha, Nebr	May	1.574	.638	.252	-------
Washington, D. C	March	2.399	.947	.325	1.8
Washington, D. C	April	.543	.390	.094	-------
Washington, D. C	May	.470	.416	.107	-------

[1] These data have been analyzed without removal of the seasonal trend.

It is, at first glance, rather disconcerting that May, the month of notable precipitation periodicity, should be lacking in significant temperature periodicities. This is particularly true at Washington, D. C., where the precipitation periodicity seemed to reach a maximum. Rather surprising in contrast are the March and April 7-day cycles at Omaha and that for March at Washington. The most significant periodicity is that shown by the April Omaha data. While it does not equal the past record periodicities [7] in either amplitude or closeness of fit (R_{28}), it still remains one of the more significant periods of record. The most curious aspect of these Omaha cycles is a tendency, pointed out by both Brier [7] and Hall [5], for the phase of the well-marked periodicities to cluster about Sunday and Monday. Further data collection and testing are necessary to prove the phase preference is real. Meanwhile it presents a stimulating subject for speculation.

The relation of periodicities to the mean circulation patterns is also of interest. It is rather remarkable that the majority of the marked periodicities studied recently in the United States have occurred in spring. An inspection of the circulation features which prevailed during some of these periodicities reveals a tendency for them to occur where the mean 700-mb. pattern indicates a fairly flat flow of westerly or zonal type often with slight cyclonic curvature and usually without marked confluence or diffluence. It may well be that the May 1952 confluence over the Middle Atlantic States augmented the usual rainfall regime, i. e., through increased overrunning of the cold flow by the periodic perturbations from the mid-United States, and that the temperature periodicities were disturbed and masked by the same cool northwesterly flow. In the case of periodicity in precipitation there was little evidence from available data that the phenomenon could be traced west of the Plains. If the pulses came from the west, as continuity suggests, the amplitude was increased in the weak United States trough. The failure to trace precipitation periodicities farther west could be due to the small amounts and infrequent occurrence of precipitation. Theoretically, the application of the fundamental Fourier Series term is best made to continuous elements, such as temperature. If, for instance, in an arid climate rain fell only on Sunday, R_{28} would be quite small despite a perfectly timed succession of pulses. Consequently, the precipitation periodicities are, other things being equal, most apt to be found where the precipitation is frequent and abundant or when an areal (rather than "pinpoint") tabulation of data is used to introduce continuity of parameter. Periodicities in meteorological elements have already been traced around the hemisphere [5] and a continuation of such studies should indicate more clearly where in the circulation pattern the sinusoidal characteristics are most marked.

In conclusion, it is obvious that 7-day periodicities were fairly common this spring. Both the April temperature at Omaha and the Washington, D. C., precipitation in May showed unusually significant persistence of weekly patterns. Whether the ultimate cause of these patterns rests in one of the natural free modes of oscillation for the atmosphere remains to be demonstrated. Currently the temperature phase preference (for Sunday-Monday) noted at Omaha is one of the most puzzling aspects of the data studied.

ACKNOWLEDGMENT

The Fourier analyses and statistical testing of the periodicities cited in the text were performed in the Meteorological Statistics Section of the United States Weather Bureau, Washington, D. C., by J. C. Coffin under the direction of G. W. Brier. The author takes this opportunity to thank them for their considerable work and advice.

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6. William Lewis, "On a Seven-Day Periodicity," Letter to Editor, *Bulletin of the American Meteorological Society*, vol. 32, No. 5, May 1951, p. 192.
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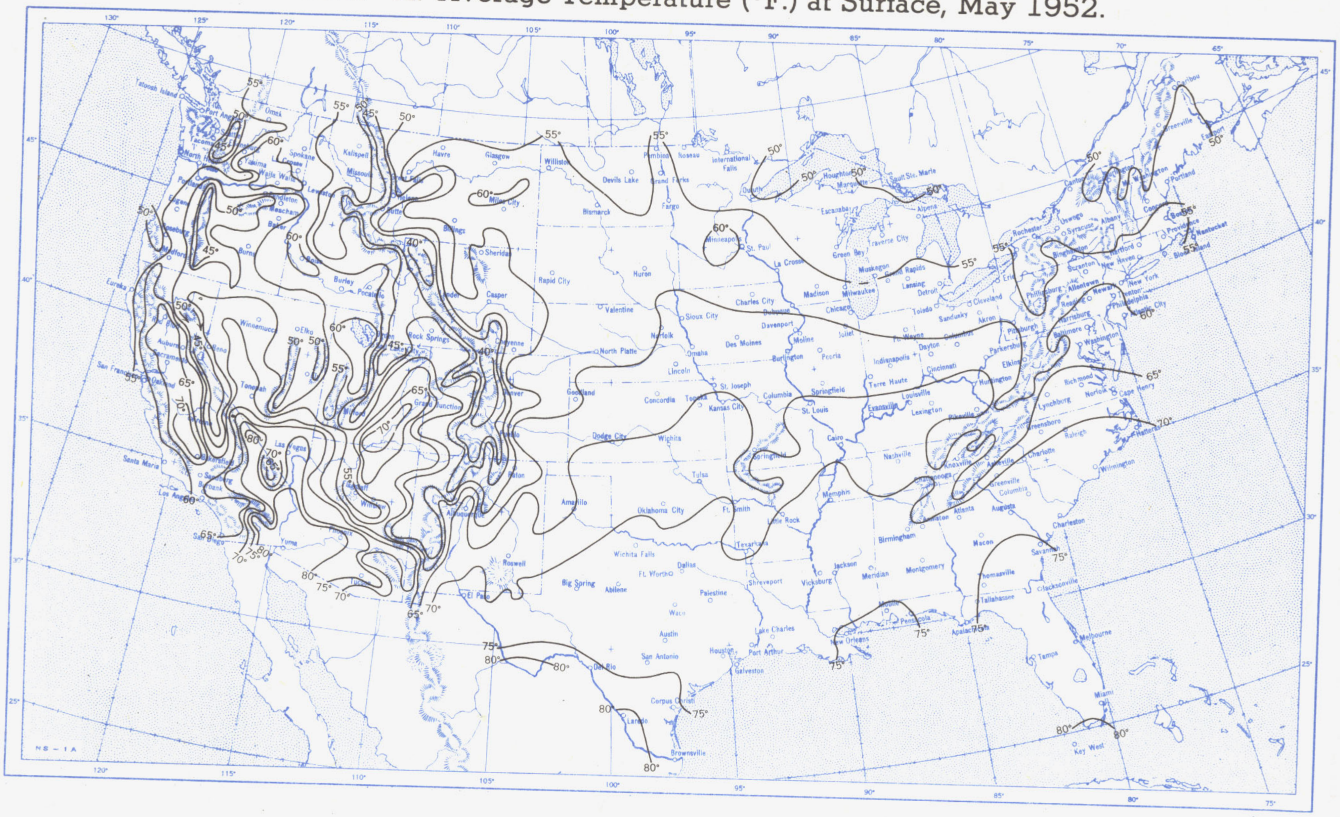
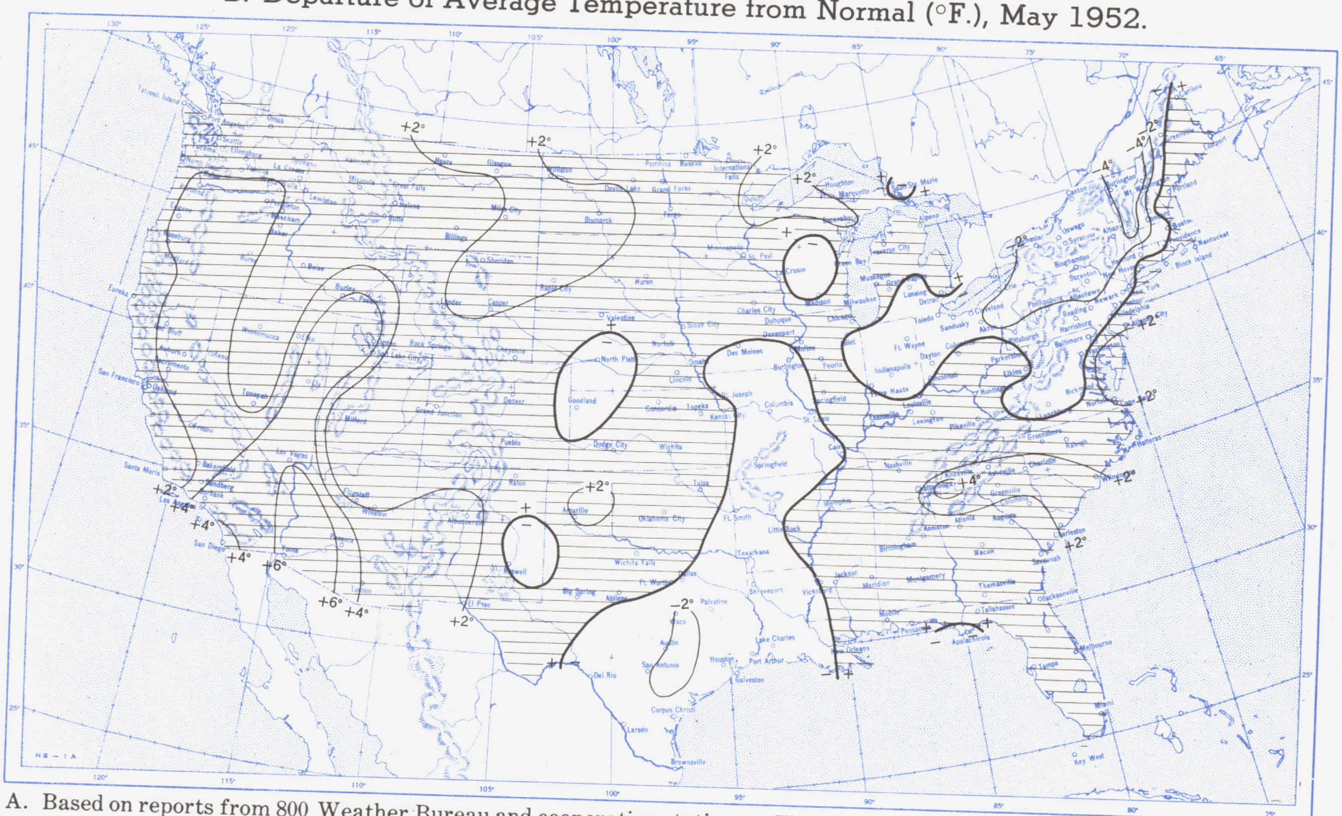
Chart I. A. Average Temperature (°F.) at Surface, May 1952.

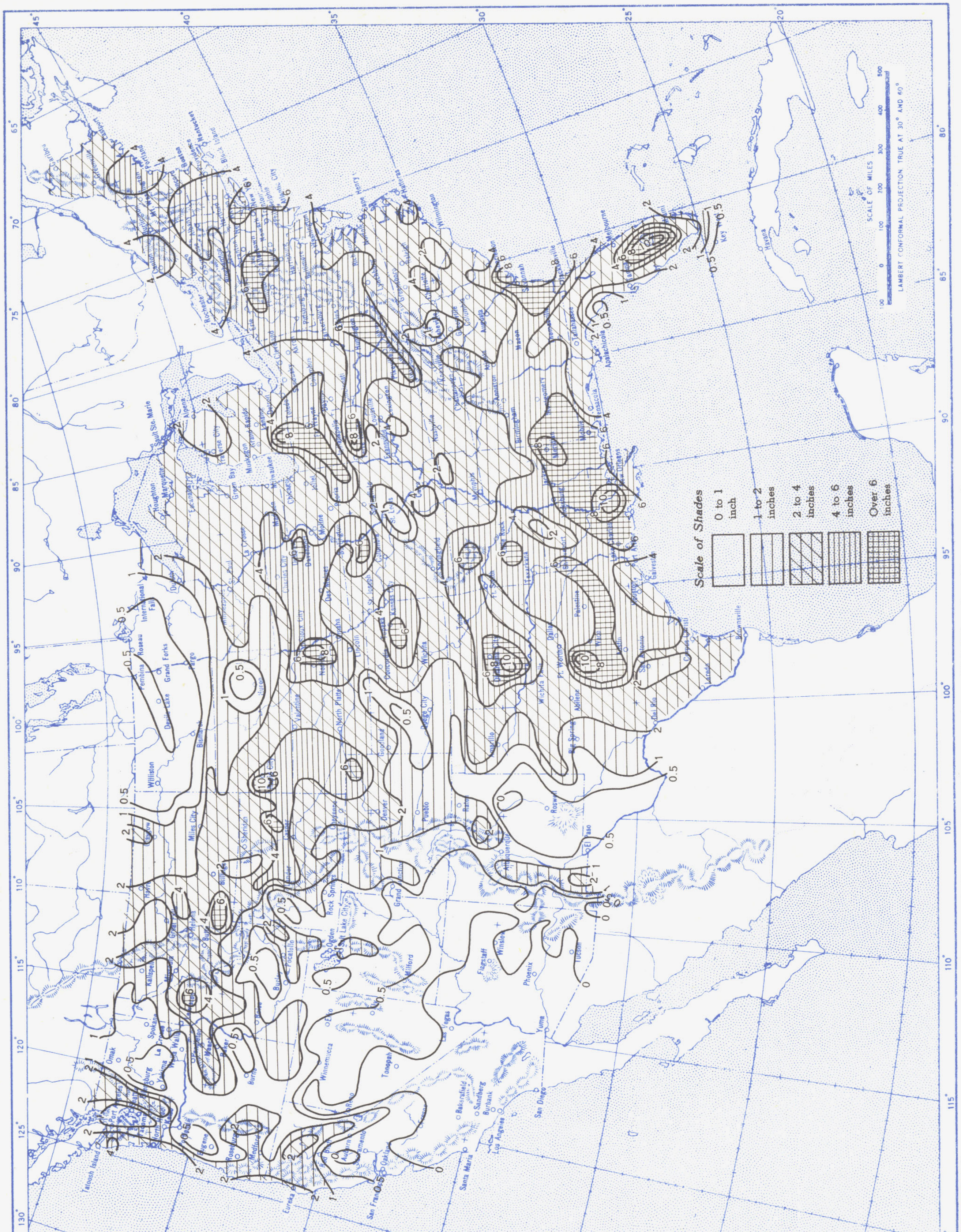


B. Departure of Average Temperature from Normal (°F.), May 1952.



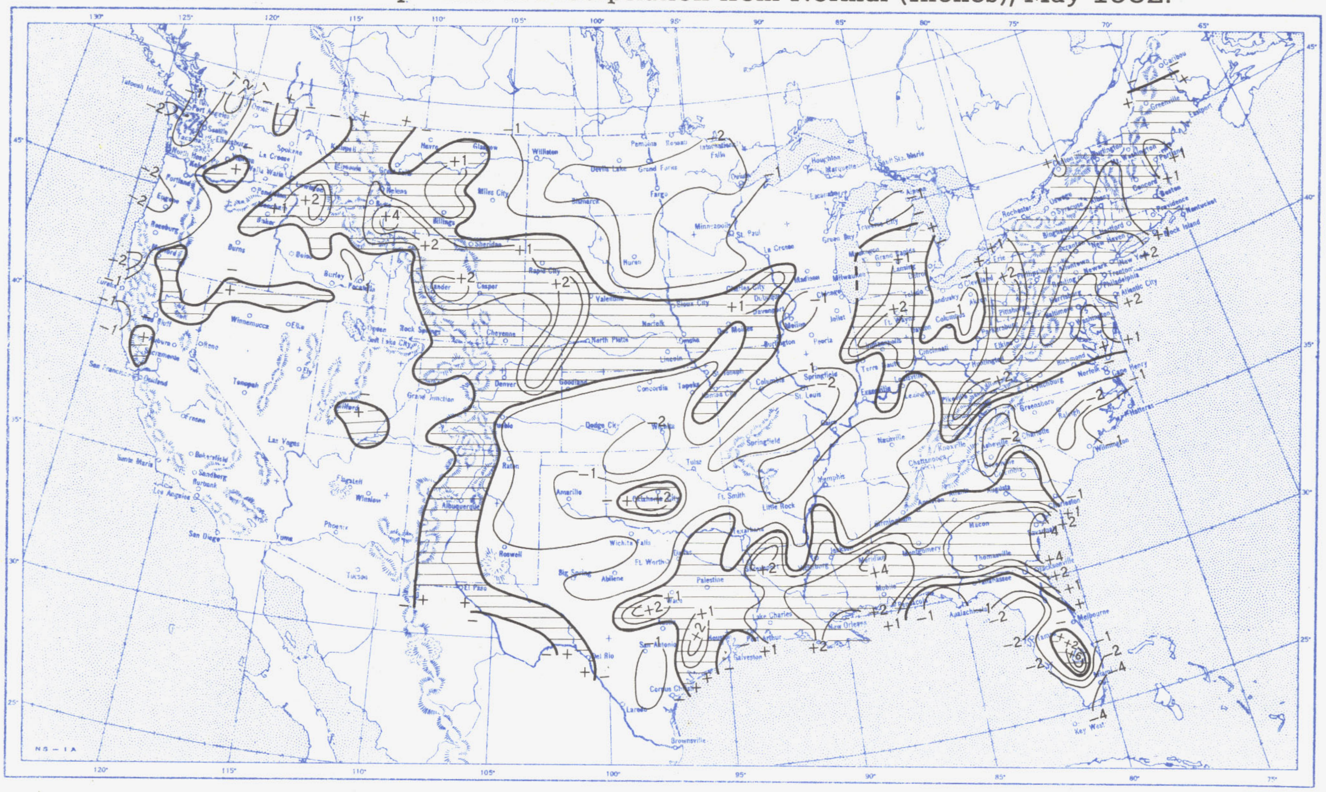
A. Based on reports from 800 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.
B. Normal average monthly temperatures are computed for Weather Bureau stations having at least 10 years of record.

Chart II. Total Precipitation (Inches), May 1952.

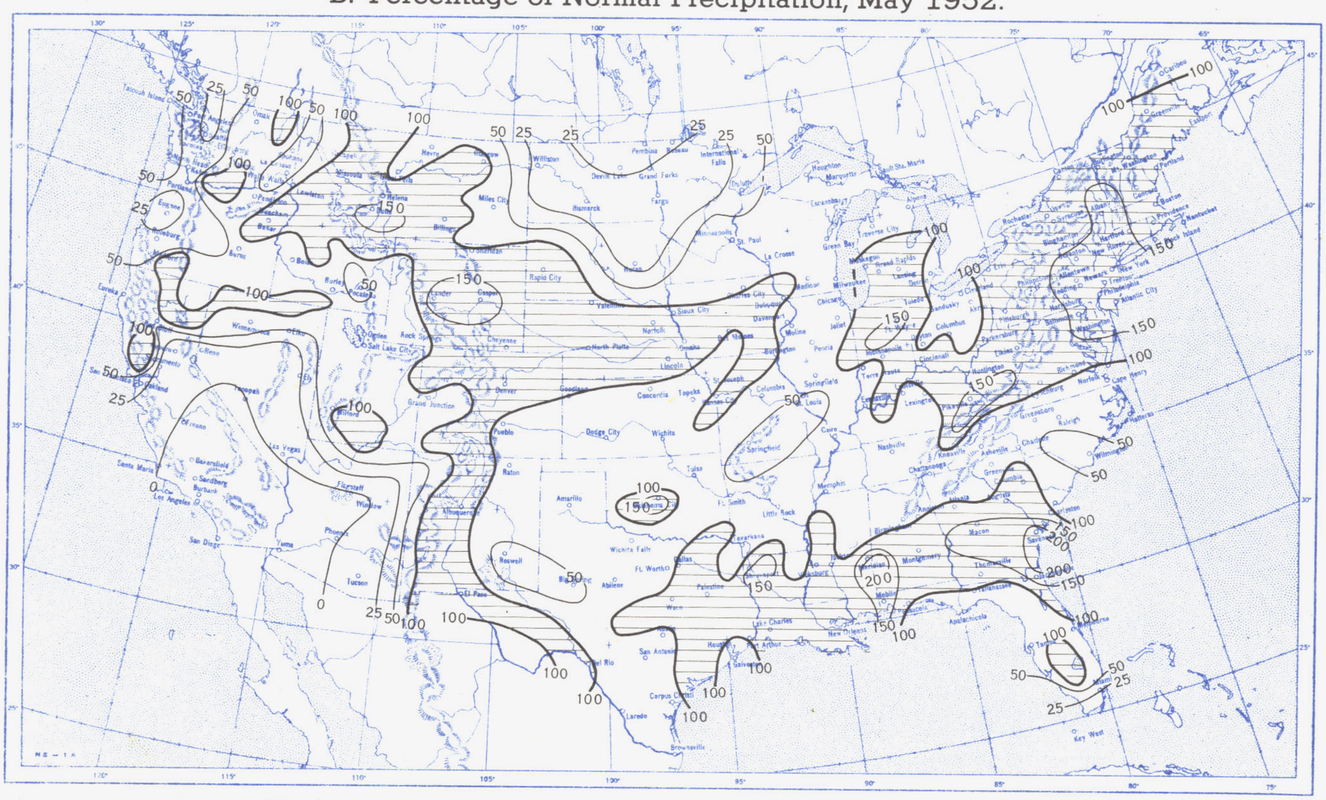


Based on daily precipitation records at 800 Weather Bureau and cooperative stations.

Chart III. A. Departure of Precipitation from Normal (Inches), May 1952.

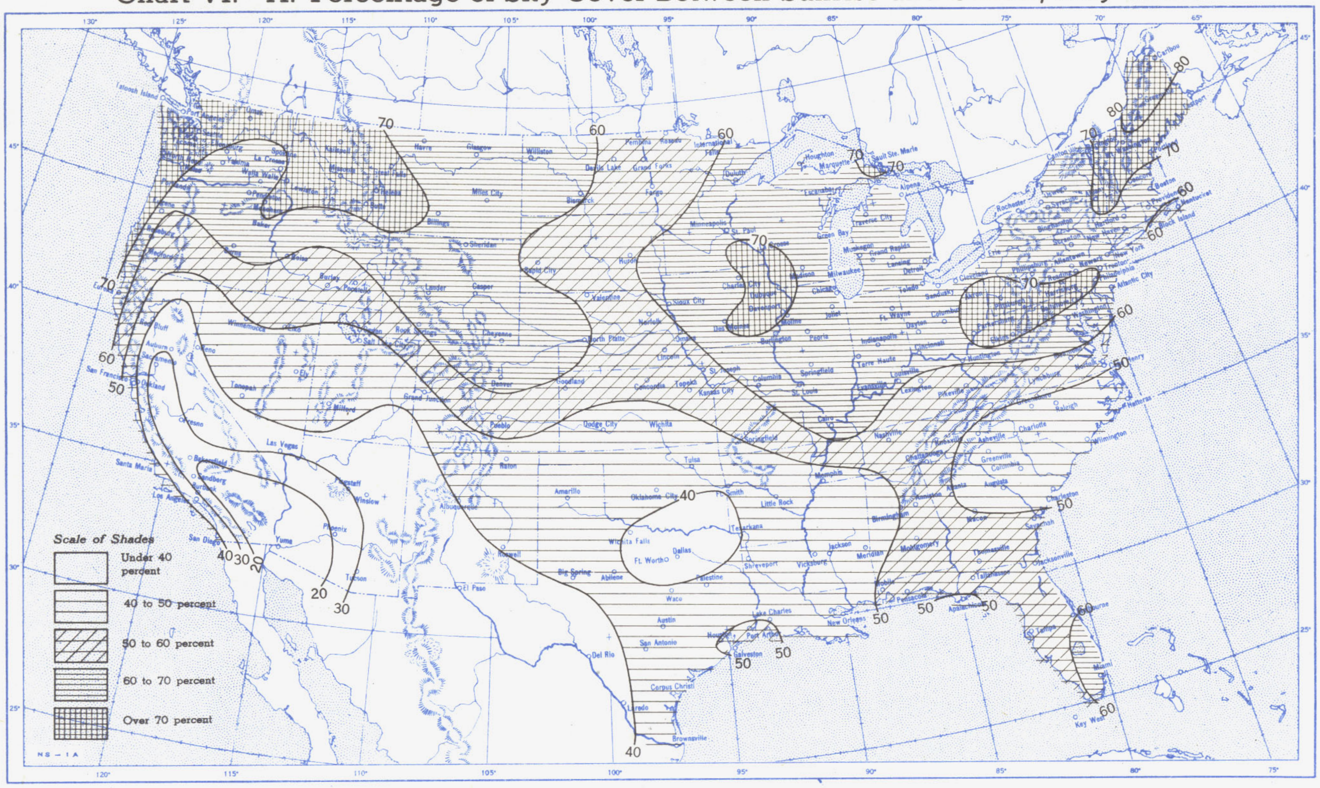


B. Percentage of Normal Precipitation, May 1952.

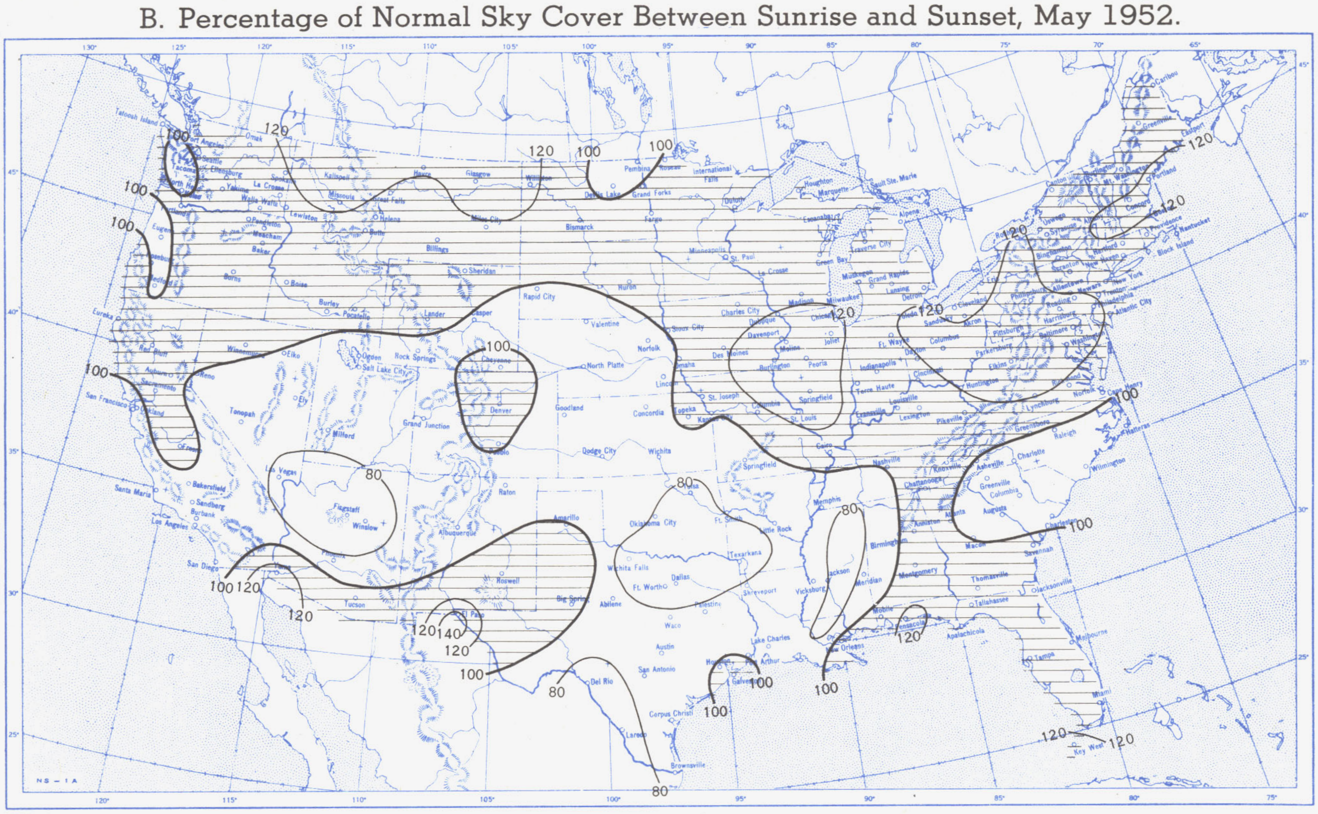


Normal monthly precipitation amounts are computed for stations having at least 10 years of record.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, May 1952.

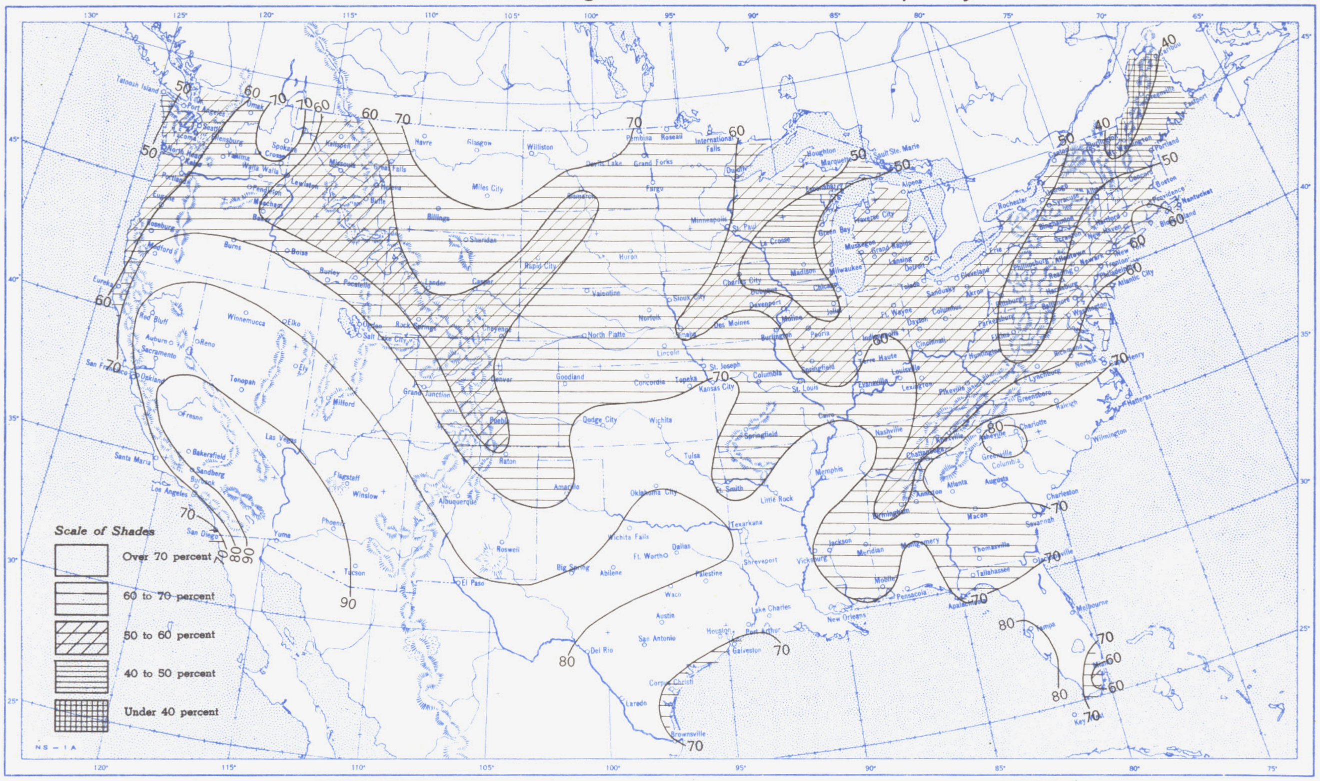


B. Percentage of Normal Sky Cover Between Sunrise and Sunset, May 1952.

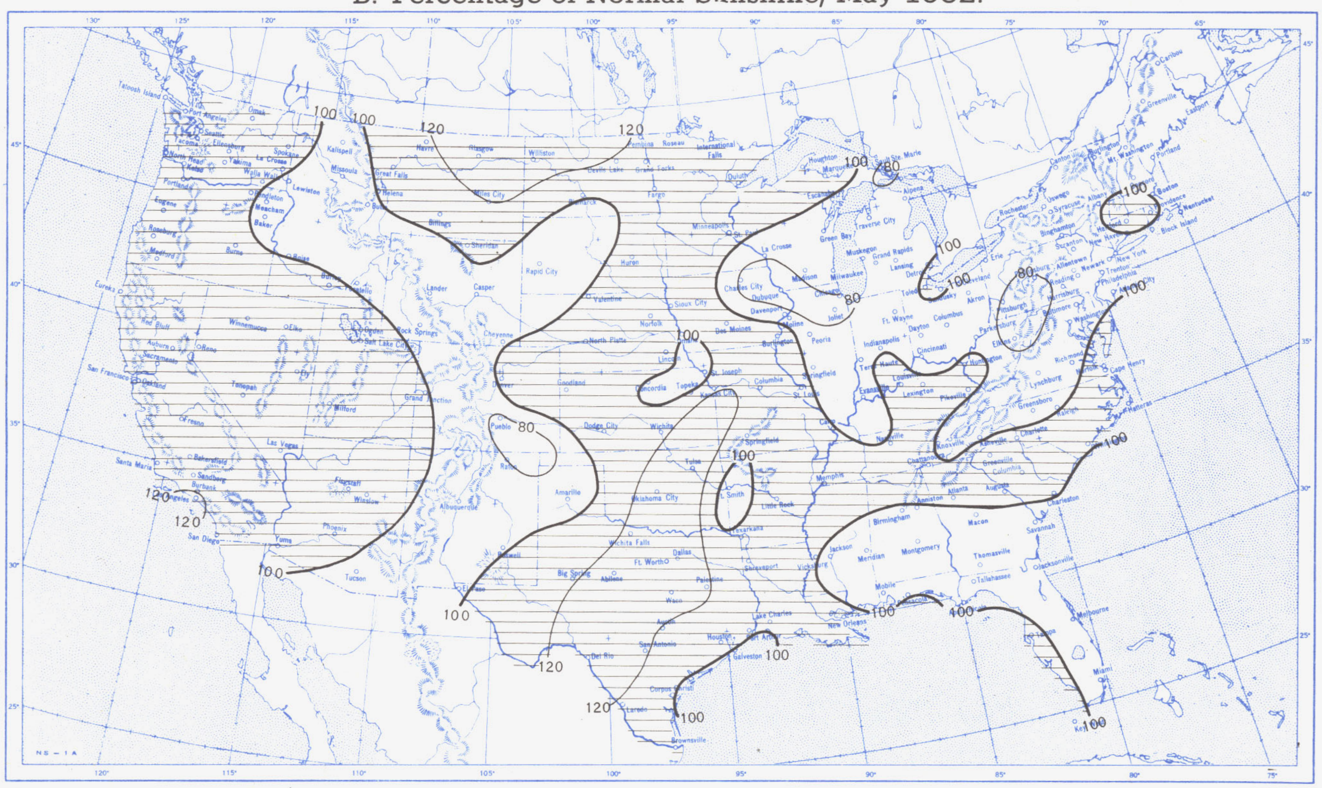


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, May 1952.



B. Percentage of Normal Sunshine, May 1952.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, May 1952. Inset: Percentage of Normal Average Daily Solar Radiation, May 1952.

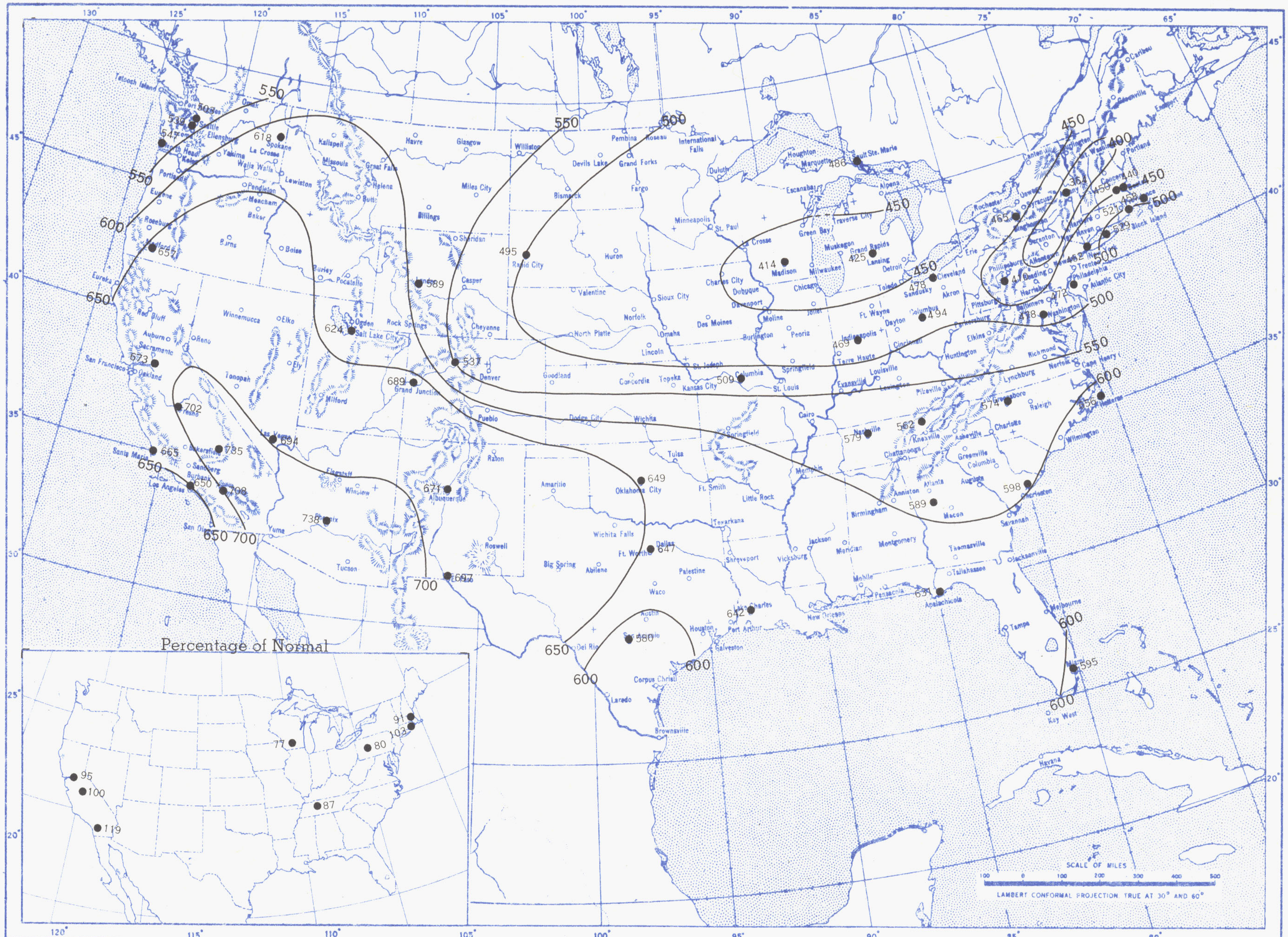
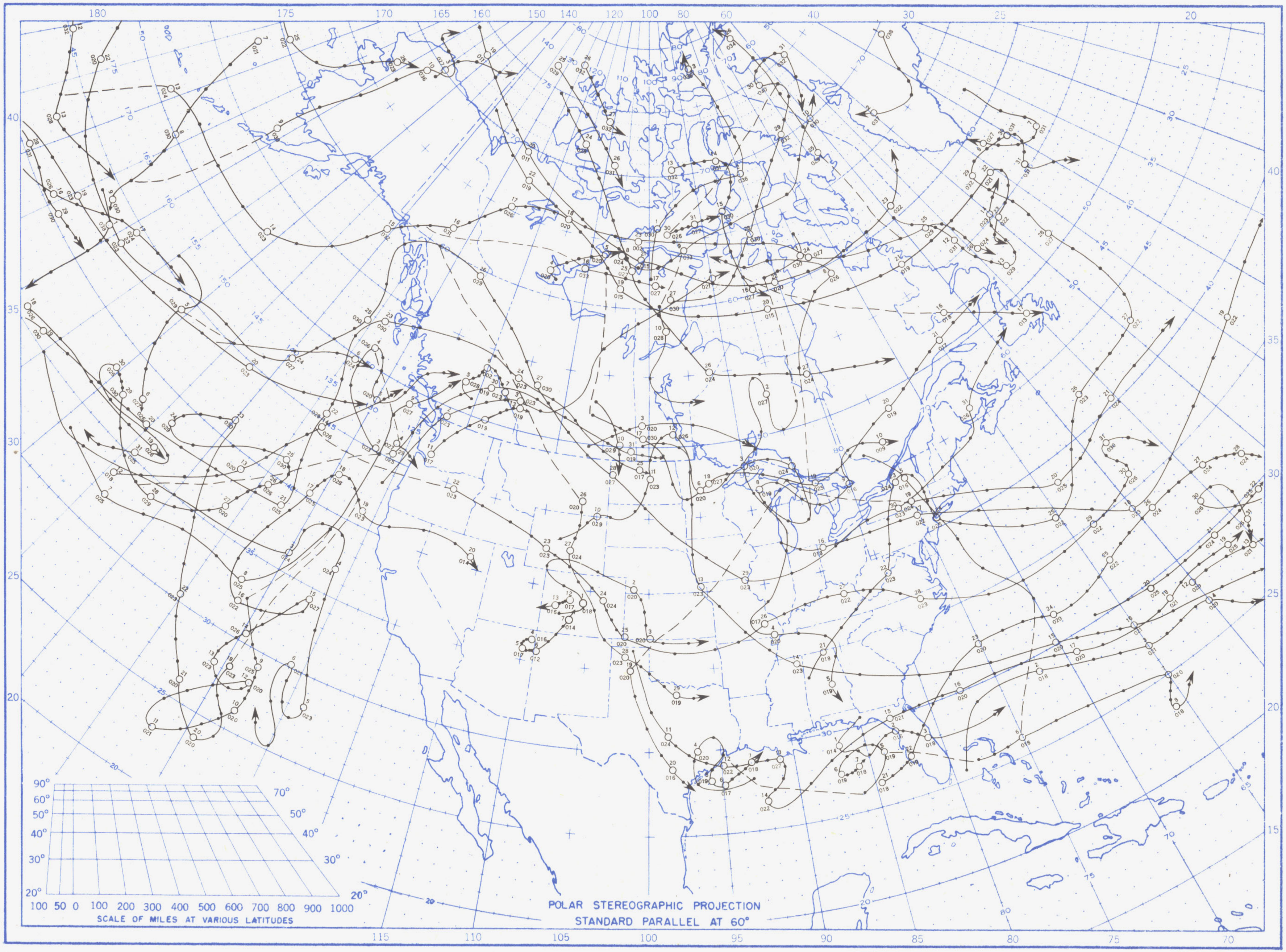


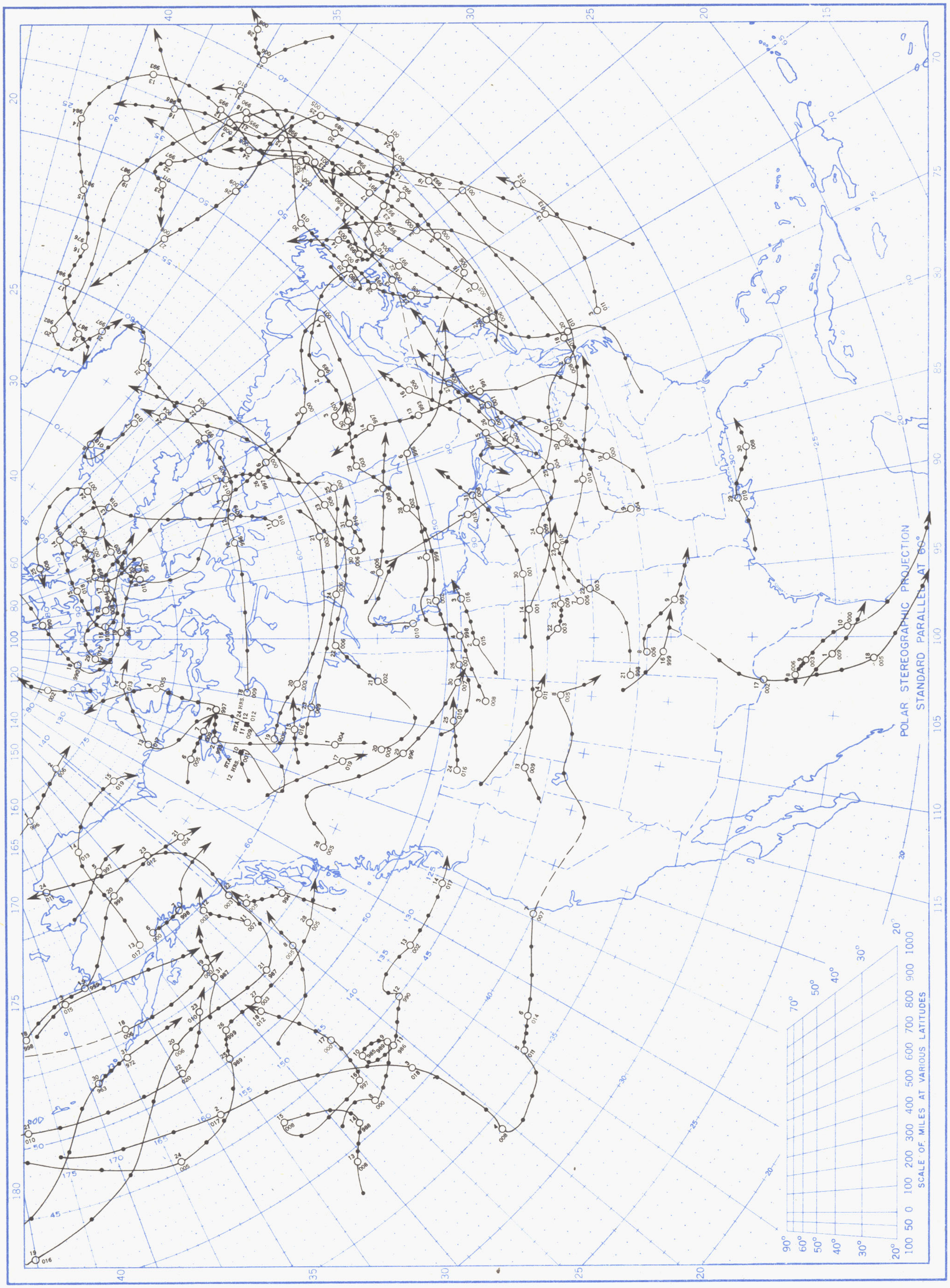
Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm.$^{-2}$). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown. Normals are computed for stations having at least 9 years of record.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, May 1952.



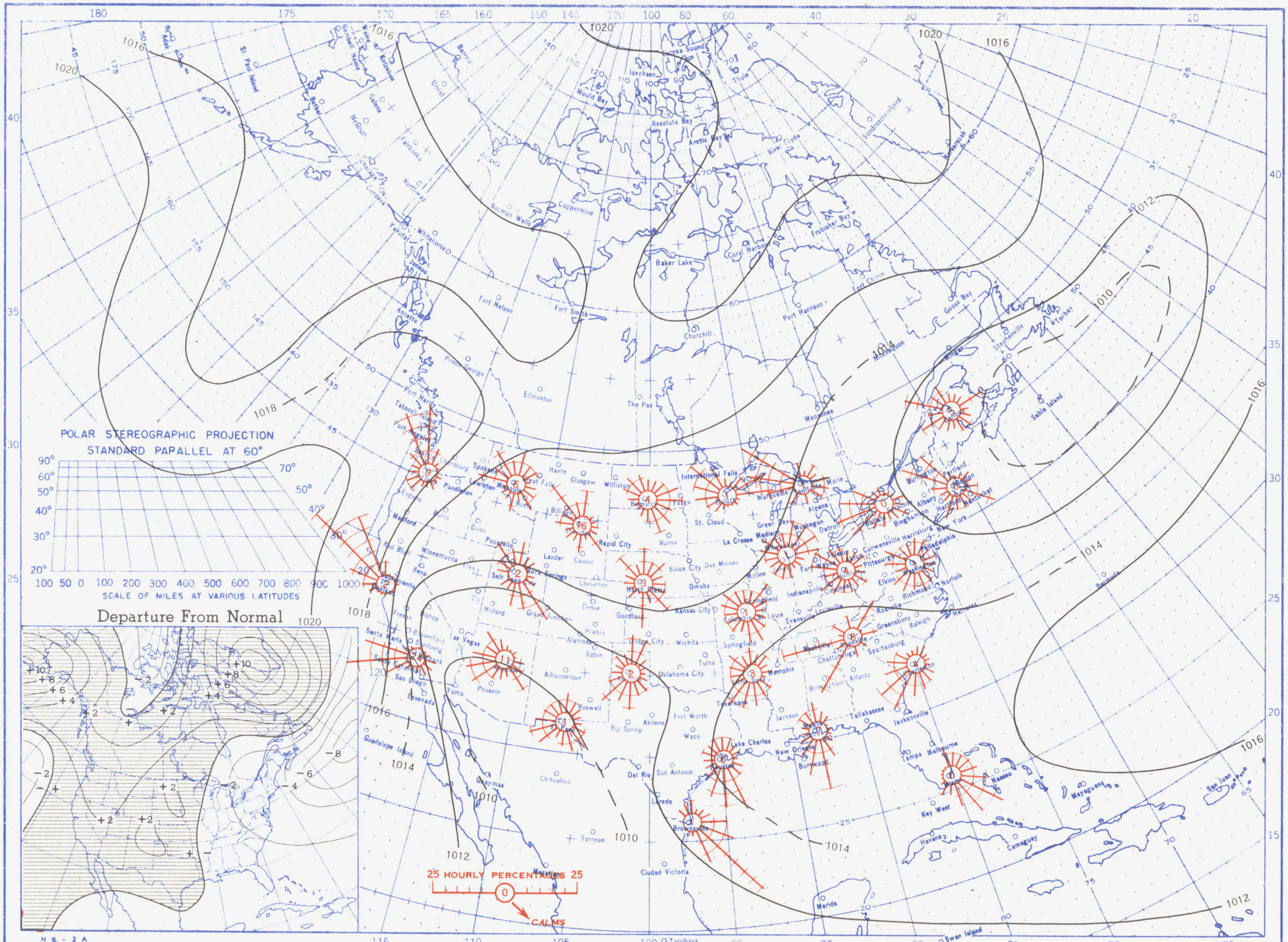
Circle indicates position of center at 7:30 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, May 1952.



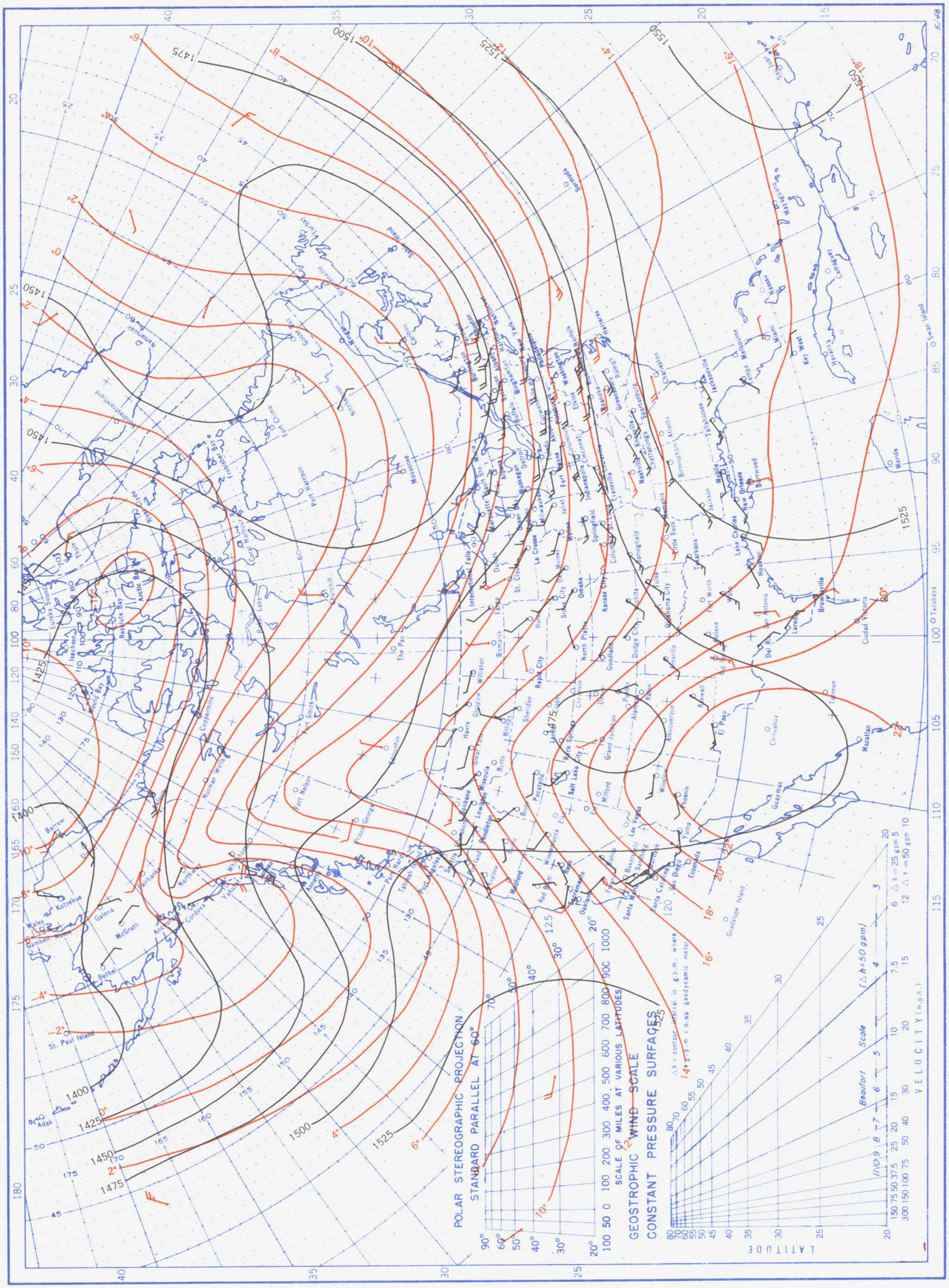
Circle indicates position of center at 7:30 a.m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, May 1952. Inset: Departure of Average Pressure (mb.) from Normal, May 1952.



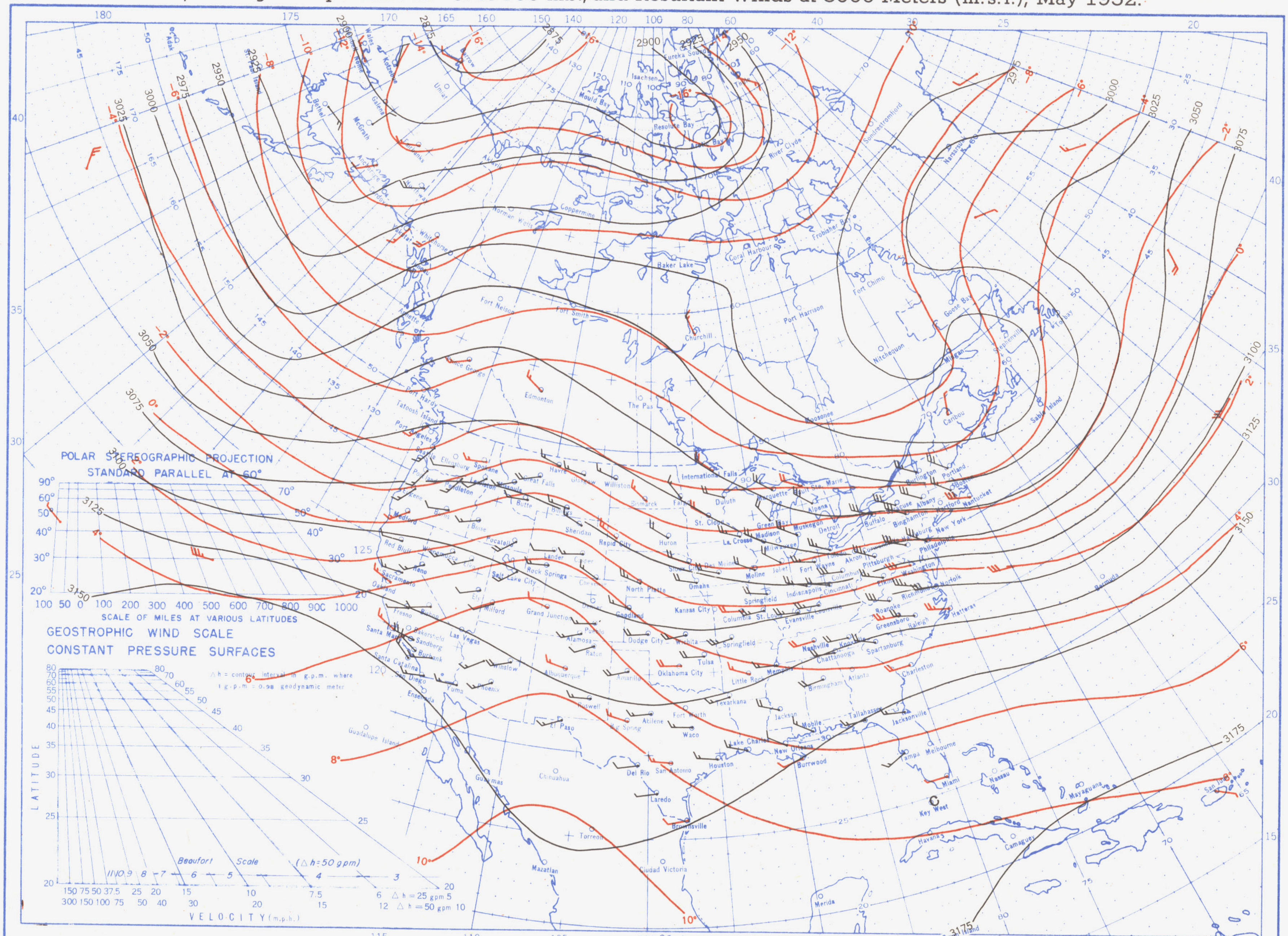
Average sea level pressures are obtained from the averages of the 7:30 a. m. and 7:30 p. m. E. S. T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 850-mb. Pressure Surface, Average Temperature in °C. at 850 mb., and Resultant Winds at 1500 Meters (m.s.l.), May 1952.



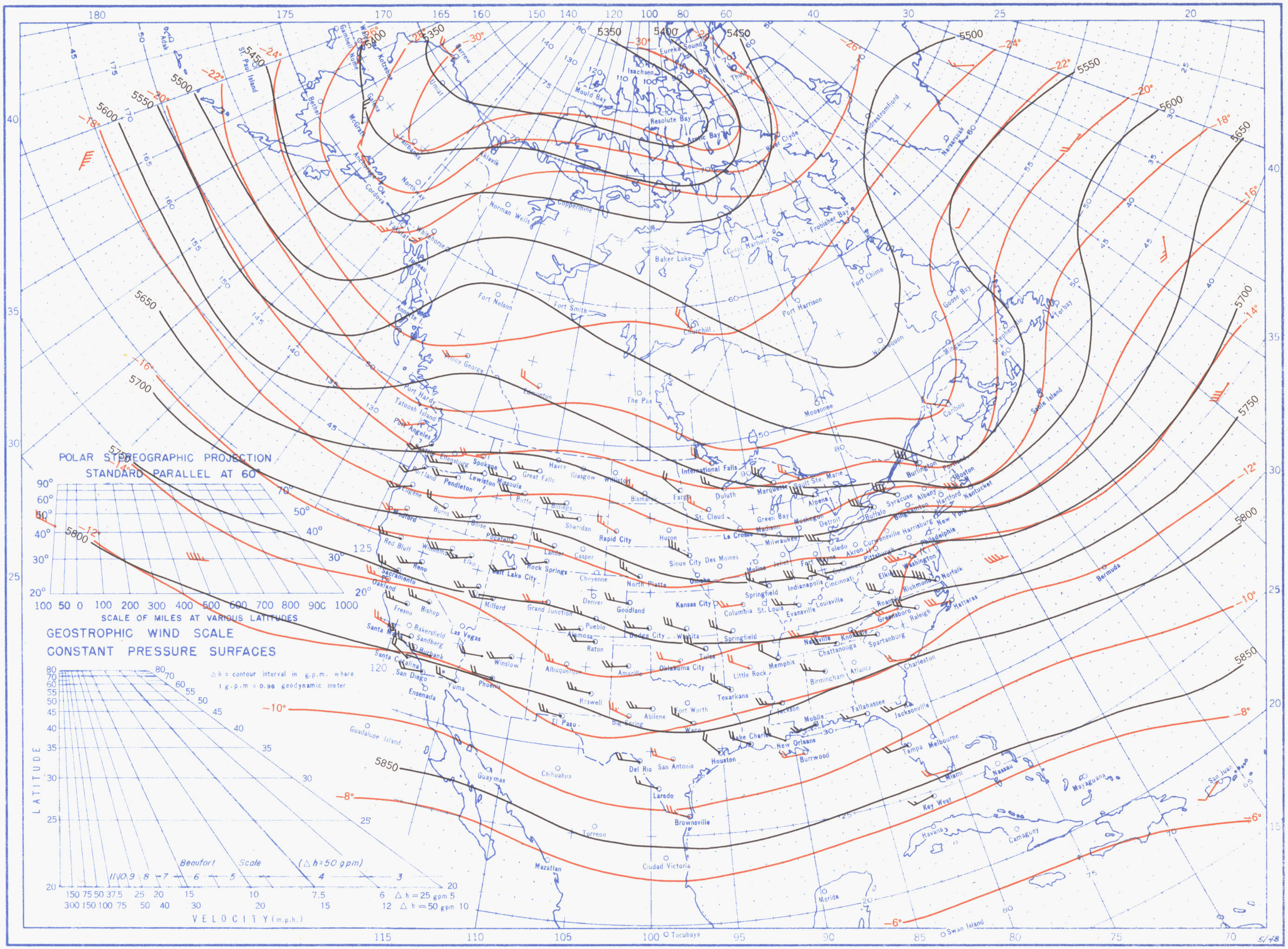
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T.

Chart XIII. Average Dynamic Height in Geopotential Meters (1 g.p.m.. = 0.98 dynamic meters) of the 700-mb. Pressure Surface, Average Temperature in °C. at 700 mb., and Resultant Winds at 3000 Meters (m.s.l.), May 1952.



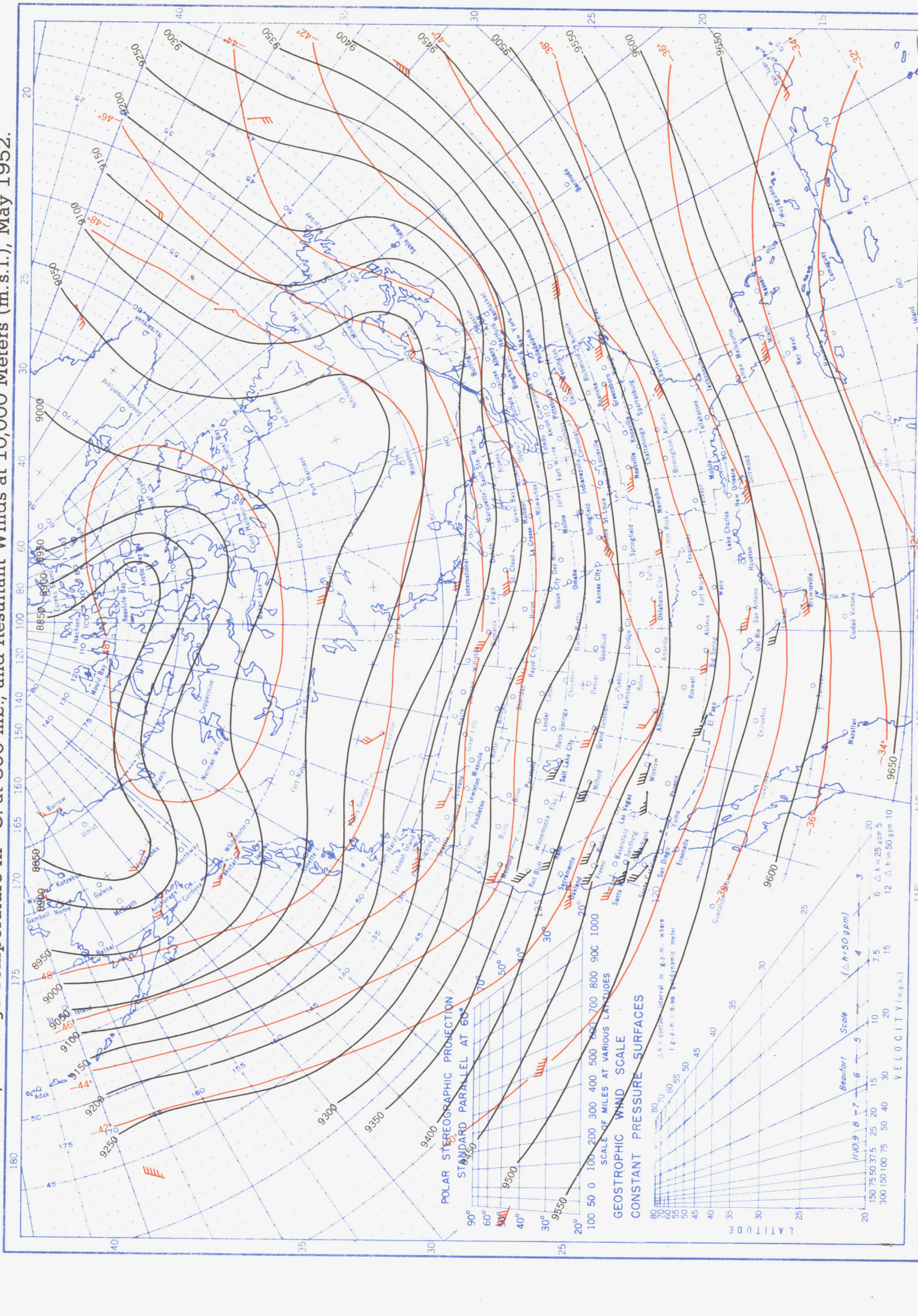
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T.

Chart XIV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 500-mb. Pressure Surface, Average Temperature in °C. at 500 mb., and Resultant Winds at 5000 Meters (m.s.l.), May 1952.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T.

Chart XV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 300-mb. Pressure Surface, Average Temperature in °C. at 300 mb., and Resultant Winds at 10,000 Meters (m.s.l.), May 1952.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T.